

DOCUMENT RESUME

ED 284 733

SE 048 278

TITLE Mathematics Achievement of Secondary School Students in Japan. NIER Occasional Paper 02/87.

INSTITUTION National Inst. for Educational Research, Tokyo (Japan).

PUB DATE Jul 87

NOTE 20p.; Prepared originally in Japanese by Toshio Sawada.

PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS Algebra; *Comparative Testing; Foreign Countries; Geometry; International Organizations; *Mathematics Achievement; Mathematics Education; *Mathematics Instruction; Measurement; *National Competency Tests; National Norms; Probability; Secondary Education; *Secondary School Mathematics; Statistics

IDENTIFIERS *Japan; Mathematics Education Research; Second International Mathematics Study

ABSTRACT

In 1980-82, the Second International Mathematics Study (SIMS) was conducted in 20 countries, including Japan. This study was conducted by the International Association for the Evaluation of Educational Achievement (IEA). This paper constitutes a summary of the research relating to the level of mathematics achievement of Japanese students. The tests administered to the students were designed to measure computation, comprehension, application, and analysis in the areas of: (1) sets, relations and functions; (2) number systems; (3) algebra; (4) geometry; (5) mathematical analysis; (6) probability and statistics; (7) measurement; and (8) finite mathematics. Scores on the tests were compared with the internationally averaged values of all 20 countries involved in the study. The achievement by Japanese students was found to be better than the international average in all content areas, but especially in the areas of geometry, algebra, and measurement.

(TW)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

ED284733

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

☒ This document has been reproduced as
received from the person or organization
originating it.

☐ Minor changes have been made to improve
reproduction quality.

• Points of view or opinions stated in this docu-
ment do not necessarily represent official
OERI position or policy.

"PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY

21. fida

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)."

NIER OCCASIONAL PAPER 02/87

MATHEMATICS ACHIEVEMENT OF SECONDARY SCHOOL STUDENTS
IN JAPAN

Section for Educational Co-operation in Asia
NATIONAL INSTITUTE FOR EDUCATIONAL RESEARCH OF JAPAN
5-22 Shimomeguro 6-Chome, Meguro-ku, Tokyo, Japan
July 1987

© NIER 1987

NOTE

This paper was prepared originally in Japanese by Mr. Toshio Sawada, Director, Research Centre for Science Education, National Institute for Educational Research (NIER), for translation into English for dissemination under the NIER's Information Services Programme among the Unesco Member States in Asia and the Pacific.

1. *Introduction*

In 1980-82, the Second International Mathematics Study (SIMS) was conducted in 20 countries including Japan. This study was carried out by the International Association for the Evaluation of Educational Achievement (IEA) in co-operation with each of participating countries.

The results of Japan have already been made public by the National Institute for Educational Research (NIER) in the following national reports.

Vol. I : Mathematics Achievement of Secondary School Students, 1981

Vol. II : Mathematics Achievement and Associated Factors of Secondary School Students, 1982

Vol. III : Mathematics Achievement and Mathematics Teaching, 1983

An international report is scheduled to be published shortly.

IEA has been co-ordinating studies on various subjects in the field of education on an international scale. Its main aim has been to clarify the relationship between various educational conditions and scholastic achievement in different countries. Comparative studies have been conducted in a number of countries chosen for their different cultural, social and economic backgrounds. The results have been published both in Japan and in the respective countries. The first of the studies of the Association was conducted in 1964 in 12 countries, including Japan. Published in 1967* as the First International Mathematics Study (FIMS), it made public for the first time the high level of achievement in mathematics of Japanese students throughout the world.

This paper constitutes a summary of the research conducted by NIER on the level of mathematics achievement of Japanese students. It is based on the results of the Second International Mathematics Study (SIMS).

2. *Target Populations and Sampling*

The international definitions of populations of examinee students were as follows:

Population A: All students in the grade level where the majority has attained the age of 13:00 - 13:11 years old by the middle of the school year.

Population B: All students who are in the normally accepted terminal grade of the secondary education system who are studying mathematics as a substantial part (approximately five hours per week) of their academic programme.

* Torsten Husen (ed.). International Study of Achievement in Mathematics: A Comparison of Twelve Countries, Vol. I & II, Almqvist & Winksell, Stockholm, 1967

In the case of Japan, Population A (Pop. A) was comprised of a sample of the first graders of lower secondary school. This took into consideration the requirement of comparability with the population in FIMS. It also met the needs of practicability. On the other hand, Population B (Pop. B) was made up of a sample of third graders in a general mathematics course or in a mathematics science course in a full-time regular curriculum in which the subject of Mathematics III is taken for more than five hours per week.

The study was carried out in both populations with samples of approximately 200 schools of 8,000 students each. The school sample was stratified by kind of school, size of school and population of the town for the sample school.

The sample data are summarized in Table 1.

Table 1: The Sample

	Pop. A	Pop. B
Students	8,091	7,954
Schools	212	192
Teachers (Classes)	212	207

The numbers of students in Population A and B correspond, respectively, to 0.5% and 4.5% of those of all students in the same grade.

3. *Construction of Instruments and their Administration*

In this study, questionnaires were addressed to the school masters, the head teachers of mathematics and the teachers of mathematics belonging to the sampled schools. The Mathematics Test and the Attitude Questionnaires were administered to students.

Items in the Mathematics Test were classified by content and objective as shown in Tables 2 and 3.

Mathematics Achievement of Secondary School Students

Table 2: Structure of Item Pool: Pop. A

Contents	O b j e c t i v e				Total
	I Compu- tation	II Compre- hension	III Applica- tion	IV Analysis	
0. Arithmetic	17	15	11	3	46
1. Algebra	18	10	8	4	40
2. Geometry	12	16	18	2	48
3. Probability and statistics	5	8	4	1	18
4. Measurement	7	7	9	1	24
Total	59	56	50	11	176

The Test was designed to be answered in two hours and included a core test composed of 40 items and a second section composed of four sets, 34 items each, offered in permuted sequence.

Table 3: Structure of Item Pool: Pop. B

Contents	O b j e c t i v e				Total
	I Compu- tation	II Compre- hension	III Applica- tion	IV Analysis	
1. Sets, Relations and Functions	2	3	1	1	7
2. Number System	4	3	6	3	16
3. Algebra	11	5	10	3	29
4. Geometry	11	7	8	3	29
5. Analysis	11	16	14	3	44
6. Probability & Statistics	3	1	3	-	7
7. Finite Mathematics	-	2	2	-	4
Total	42	37	44	13	136

The second set of test items of 136 items in total was decomposed into eight kinds of test sets composed of 17 items each. A Test to be answered in two hours was composed of two of the sets for each student.

The study was carried out at the beginning of the school year (May 1980; pre-test) and at the end of the school year (March 1981; post-test) for the first graders of the lower secondary school, and in November 1980 for the 3rd graders of the upper secondary school.

The Opportunity to Learn (OTL) for each item was also asked to teachers and students.

4. Summary of the results

4.1 Item Difficulties

In the study, the Mathematics Test was carried out with 176 items for Pop. A, and 136 items for Pop. B. Figure 1 shows the distribution of the percentage of correct answers for each item. For Pop. A, the average percentage of correct answers (average difficulty) is 62.5% (with the standard deviation S.D.=19.2). The distribution peaks at around 60%, and 148 test items out of 176 (84%) fall within the range of 40-80% of correct answers.

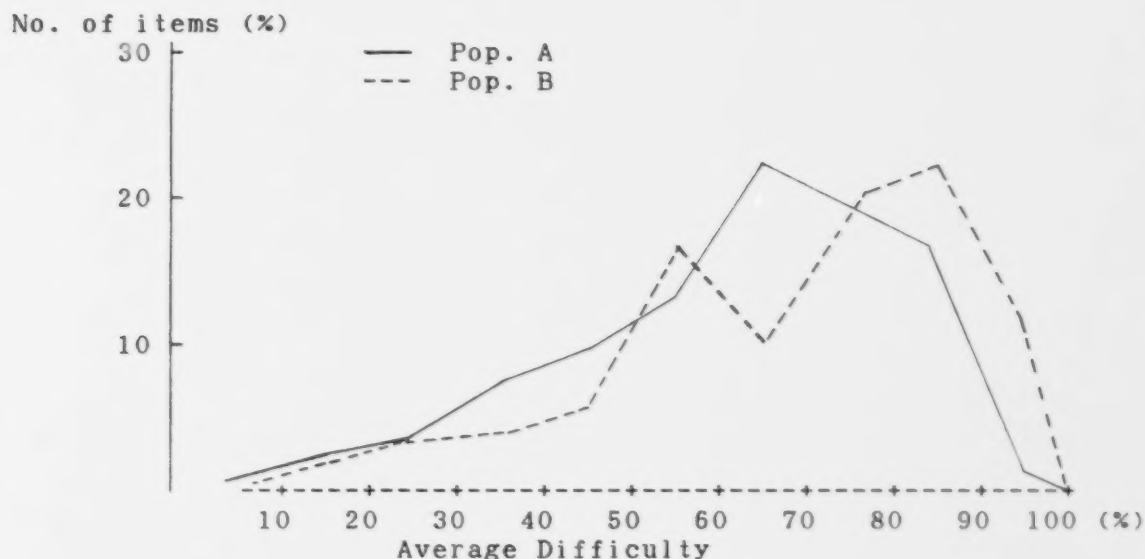


Figure 1: Distribution of Item Difficulty

On the other hand, for Pop. B, the average percentage of correct answers against 136 items is 69.2% (S.D.=19.6), and the percentage distribution has its peak at around 80%. But, the distribution is divided into two groups. That is, the distribution of percentage of correct answers for each item suggests a sub-group of easy items and that of difficult ones.

For Pop. A and Pop. B, there were three and six items respectively, which were so difficult for students that the percentage of correct answers was less than 20%. For Pop. A, they were items concerning the root, vector, and transformation, all of which had not been taught by the time of the test. For Pop. B, they were items about complex numbers, projective geometry, etc., which had also not been taught.

The following items exhibited the lowest percentage of correct answers in spite of the fact that they were high (more than 90%) in the Opportunity to Learn Ratings (OTL).

Population A

"In a school of 800 pupils, 300 are boys. The rate of the number of boys to the number of girls is."

[A 3:8 B 5:8 C 3:11 D 5:3 E 3:5]

Correct answer: E: 31.5% OTL: 97%

Wrong answers: D: 40.3%
 A: 23.2%
 B: 3.1%
 C: 1.1%

Population B

"Let P be a polynomial of x of degree m, and Q a polynomial of x of degree n, and let $n < m$. What is the degree of the polynomial $(P+Q)(P-Q)$? Choose from below."

[A $2m$ B m^2 C mn D n^2 E $m^2 - n^2$]

Correct answer: A: 37.3% OTL: 99%

Wrong answers: D: 30.5%
 B: 25.4%
 C: 4.7%
 E: 1.5%

On the other hand, the following test items exhibited the highest percentage of correct answers.

Population A

"Which of the following is most likely to be nearest to the weight of a normal man? Choose from below."

[A 8.5kg B 85kg C 185kg D 850kg E 1,850kg]

Correct answer: B: 93.0% OTL: 91.6%

For Japanese children this problem is easy because the metric system is well-adopted in Japan. But children in English-speaking countries (especially in U.S.A., England, Canada, etc.) chose a wrong one [C 185kg] more than the correct one [B 85kg], understandably misinterpreting kg as "pounds"

In fact the percentages of correct answers were 35% and 36%, for students in U.S.A. and England respectively, which were the lowest among those in the participating 20 countries.

Population B

"The solution set for the equation $(1-2x)(2+x)=0$ is"

A $\{1/2, -2\}$; B $\{-1/2, 2\}$; C $\{-1, -2\}$; D $\{1/2, 2\}$; E $\{2, -2\}$

The correct answer is A and the percentage of correct answers was 95.3%, and OTL was 100.0%.

4.2 Average difficulty by Content and Objective Area

Tables 4 and 5 show the average percentage of correct answers calculated for each area of content. As far as the achievement of students in each area of content is concerned, for Pop. A (students of lower secondary schools), Probability and Statistics, and Measurement are better than others. For Pop. B (students of upper secondary schools), the achievement in Geometry is worse than that of other areas.

Table 4: Average percentage of correct answers in each area of content: Pop. A

Content	No. of Items	Average Correct (%)
Arithmetic	46	60.5
Algebra	40	60.6
Geometry	48	59.6
Probability and Statistics	18	71.1
Measurement	24	68.8
Overall	176	62.5

Table 5: Average percentage of correct answers in each area of content: Pop. B

Content	No. of Items	Average Correct (%)
Sets, Relations and Functions	7	79.7
Number system	16	71.8
Algebra	29	75.5
Geometry	29	57.7
Analysis	44	69.1
Probability and Statistics	7	71.8
Finite Mathematics	4	76.2
Overall	136	69.2

Mathematics Achievement of Secondary School Students

Tables 6 and 7 show the average percentage of correct answers calculated for each level of understanding - Computation, Comprehension, Application and Analysis - according to the nature and the degree of difficulty of the test items.

Table 6: Average percentage of correct answers in each objective area: Pop. A

Objective	No. of Items	Average Correct (%)
Computation	59	66.3
Comprehension	56	57.9
Application	50	64.2
Analysis	11	58.3
Overall	136	62.5

Table 7: Average percentage of correct answers in each objective area: Pop. B

Objective	No. of Items	Average Correct (%)
Computation	42	73.3
Comprehension	37	66.0
Application	44	69.1
Analysis	13	65.7
Overall	136	69.2

For Pop. A, the percentage of correct answers averaged overall items is 62.5%. When each area of objectives is examined separately, a significant difference is observed between achievement in the area of Computation and Application and that in the area of Comprehension and Analysis.

For Pop. B, the percentage of correct answers averaged overall items is 69.2%. Student achievement in the area of Computation appears relatively better, while in the area of Analysis, it is relatively worse than others.

4.3 Change in Achievement Between 1964 and 1980-81

For the current study (SIMS), some items were replicated from those of the previous research (FIMS) in order to compare achievement levels at the different times.

For Pop. A, there were 37 common items over all the tests. Table 8 shows a comparison of achievement between FIMS and SIMS classified according to objective and to form (whether verbal problems or non-verbal calculation).

Table 8: Achievement in FIMS/SIMS: Pop. A

Area	No. of common items	FIMS (%)	SIMS (%)	Change (%) (SIMS - FIMS)
Overall	37	64.6	64.3	-0.3
Computation	13	63.8	67.2	3.4
Comprehension	11	55.9	54.6	-1.3
Application	10	75.8	71.2	-4.6
Analysis	3	63.3	64.6	1.3
Non-verbal	20	60.0	62.8	2.8
Verbal	17	70.1	66.1	-4.0

Overall achievement was 64.6% for FIMS and 64.3% for SIMS, the difference being 0.3%; hence there was essentially no change in achievement between the two. If they are seen from the point of each objective, however, the achievement in this time improved by 3.4% in the area of Computation, but diminished by as much as 4.6% in the area of Application.

Furthermore, if the items are classified into verbal or non-verbal, the difference in achievement becomes more marked. Achievement improved by 2.8% over the time period for non-verbal problems, but it declined by as much as 4% for verbal items.

Let us compare achievement in this and the previous studies for each item separately. The item, which had already been taught by the previous school year and which showed the greatest improvement in achievement in this time was the following one.

$$" \frac{2}{5} + \frac{3}{8} = "$$

[FIMS: 84% SIMS: 89% Difference: 5%]

Conversely, the following examples are items for which achievement levels were lower in the second study.

"A runner ran 3,000 meters in exactly 8 minutes. What was his average speed in meters per second?"

[FIMS: 51% SIMS: 38% Difference: -13%]

$$"0.40 \times 6.38 = "$$

[FIMS: 75% SIMS: 63% Difference: -12%]

Mathematics Achievement of Secondary School Students

Other examples confirm a general trend of higher achievement in the second study for test items of basic calculation and lower achievement for verbal items or items requiring a high degree of thinking.

Let us next compare the achievement for common items in FIMS and SIMS for Pop. B.

Table 9: Achievement in FIMS/SIMS: Pop. B

Area	No. of common items	FIMS (%)	SIMS (%)	Change (%) (SIMS - FIMS)
Overall	19	60.7	76.4	15.7
Computation	6	73.0	86.4	13.4
Comprehension	6	53.2	72.8	19.6
Application	7	56.5	71.0	14.5
Analysis	0	-	-	-
Non-verbal	14	55.8	74.9	19.1
Verbal	5	74.2	80.9	6.7

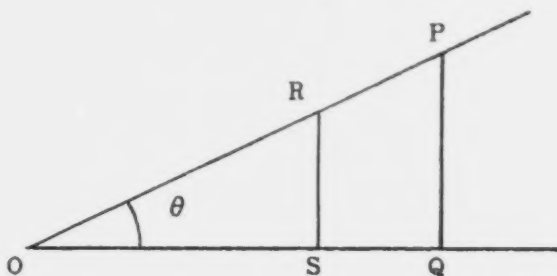
For Pop. B, there are 19 common items, and Table 9 shows the comparison of the achievement between FIMS and SIMS classified according to objective and form (verbal problems or non-verbal calculation).

For Pop. B, achievement improved in all areas compared to the previous study. The chosen population was the same as in the previous study, namely, the third graders of upper secondary schools who were registered in a college-bound science course. The difference between the two studies was, however, that the starting time of the SIMS study was in November, four months later than the previous study, which was in July. Especially since a long summer vacation intervened between the two periods, the effect of preparation study for college during the vacation may be suspected as one major cause of difference.

In spite of this, for the following two items students registered worse scores than those in the previous study.

"In the figure below, let $\overline{PQ} \perp \overline{OQ}$ and $\overline{RS} \perp \overline{OQ}$. If $\overline{OQ} = \overline{OR} = 1$ and $\angle POQ = \theta$, then the measure of segment $\overline{PQ}$ is equal to"

- A: $\sin \theta$
- B: $\cos \theta$
- C: $\tan \theta$
- D: $2\sin \theta$
- E: $1 - \cos \theta$



Correct answer: C
[FIMS: 81% SIMS: 74% Difference -7%]

$$\lim_{h \rightarrow 0} \frac{\sqrt{2+h} - \sqrt{2}}{h} = "$$

[FIMS: 59% SIMS: 53% Difference: -6%]

These items were more basic and fundamental than other common items.

4.4 Growth of Score between Pre-test and Post-test for Pop. A

For students in Pop. A, a pre-test at the beginning and a post-test at the end of the school year were conducted with 60 common items in order to see whether achievement improved during the period. The change in percentage of correct answers is examined below for 32 of the 60 items which had already been taught in the previous year (at the elementary school).

Table 10 shows the percentage of correct answers in the pre-test (X) and the post-test (Y), and the percentage of answers which were correct both in pre- and post-tests ($X \cap Y$).

Table 10: Change in Achievement between Pre- and Post-tests

Content	Pre-test (X)	Post-test (Y)	$X \cap Y$
Arithmetic	54.1	57.8	36.9
Algebra	59.3	62.6	40.7
Geometry	64.9	72.2	51.0
Statistics	59.0	63.4	43.0
Measurement	63.9	68.5	49.6
Overall	58.2	62.5	42.1

As an example, in the content of Arithmetic, the percentage of correct answers was 54.1% in the pre-test, whereas it was 57.8% in the post-test, an apparent increase of 3.7%. But only 36.9% of the students answered correctly both in pre- and post-tests. In other words, Table 10 shows that 17.2% of the students who had answered correctly in the pre-test answered wrongly in the post-test, while 20.9% who had had the incorrect answer in the pre-test had the correct answer in the post-test.

In this way, by judging from the real percentage of correct answers (the percentage of those who answered correctly both in pre- and post-tests), it can be found that the percentage of those who gave a correct answer in the pre-test but failed to do so in the post-test is, respectively, 18.6% in Algebra, 13.9% in Geometry, 16.0% in Statistics, and 14.3% in Measurement. The corresponding figures for improved performance are 21.9% in Algebra, 21.2% in

Geometry, 20.4% in Statistics, and 18.9% in Measurement.

Guessing from the results of these studies on the contents which had already been taught to students, it can be concluded that the value obtained by subtracting approximately 16% from the (apparent) percentage of correct answers should be regarded as the real percentage of correct answers. This value may also be regarded as an index of fixedness of the test items to students.

Here, examples of the items are given. The following are the items for which the percentage of correct answers was low.

"A runner ran 3,000 meters in exactly 8 minutes. What was his average speed in meters per second?"

Pre-test (X): 33.1% Post-test (Y): 37.7%
Correct in both tests ($X \cap Y$): 16.8%

"In a school of 800 pupils, 300 are boys. The rate of the number of boys to the number of girls is"

Pre-test (X): 33.6% Post-test (Y): 31.5%
Correct in both tests ($X \cap Y$): 11.9%

"1st row	1
2nd row	1 - 1
3rd row	1 - 1 + 1
4th row	1 - 1 + 1 - 1
5th row	1 - 1 + 1 - 1 + 1

What is the sum of the 50th row?"

Pre-test (X): 35.1% Post-test (Y): 42.0%
Correct in both tests ($X \cap Y$): 18.1%

"30 is 75% of what number?"

Pre-test (X): 45.7% Post-test (Y): 46.6%
Correct in both tests ($X \cap Y$): 27.7%

These are verbal items which require a complex operation of thinking, and are examples of items for which the performance was relatively low.

Next, examples of items for which the percentage of correct answers was high are given in the following.

$$" \quad \frac{2}{5} + \frac{3}{8} = \quad "$$

Pre-test (X): 83.8% Post-test (Y): 88.8%
Correct in both tests ($X \cap Y$): 77.5%

This is an easy item involving calculation of fractional numbers, also with a high degree of performance.



"In the figure above, the length of AB is 1 unit. Which is the best estimate for the length of PQ?"

[A: 2 B: 6 C: 10 D: 14 E: 18]

Pre-test (X): 81.8% Post-test (Y): 87.0%
Correct in both tests ($X \cap Y$): 73.1%

These examples show that for items which require a full understanding of their contents for solution (that is, for such problems which belong to the so-called verbal item domain), the degree of fixedness is low.

5. *INTERNATIONAL COMPARISON IN ACHIEVEMENT*

5.1 Achievement Comparison by Topic

Tables 11 and 12 show the data on achievement of Japan together with the internationally averaged values over 20 countries for each content, constructed by using the so-far known data. This is a preliminary form of the international comparison of the achievement in each country, the full form of which will later be published in the International Report.

The number of items used here is smaller than that actually employed in the study because only those items were selected for which a common comparison was possible by examining the real condition of the Opportunity to Learn Ratings (OTL) for each country. According to this criterion, 157 items for Pop. A and 129 items for Pop. B became the subject of comparison.

Table 11 shows the data for our country and the international average (average over 20 countries) for each content area.

The "Mean" stands for the mean value of the percentage of correct answers, and "SD" for the standard deviation calculated from the average values for each country. The calculation of the "Z-score" for Japan was based on the international average.

The Japanese achievement is better than the international average in all content areas, but especially in the areas of Geometry, Algebra, and Measurement.

Table 11: Achievement Comparisons by Topic: Pop. A

Content	(no. of items)	Japan		International	
		Mean (%)	Z-score	Mean (%)	S.D.
Arithmetic	(46)	60.3	1.31	50.5	7.47
Algebra	(30)	60.3	2.01	43.1	8.56
Geometry	(39)	57.6	2.07	41.4	7.84
Probability & Statistics	(18)	70.9	1.79	54.7	9.05
Measurement	(24)	68.6	2.02	50.8	8.83
Overall	(157)	62.1	2.03	47.5	7.18

Note: $Z = (\text{National Mean} - \text{International Mean}) / \text{International S.D.}$

Table 12: Achievement Comparisons by Topic: Pop. B

Content	(no. of items)	Japan		International	
		Mean (%)	Z-score	Mean (%)	S.D.
Sets, Relations & Functions	(7)	78.6	1.34	61.6	12.70
Number systems	(17)	68.3	1.46	49.5	12.86
Algebra	(26)	77.8	1.74	57.5	11.64
Geometry	(26)	60.0	1.70	42.4	10.37
Analysis	(46)	66.1	1.51	44.1	14.54
Probability & Statistics	(7)	70.0	1.55	49.5	13.25
Overall	(129)	68.4	1.63	48.4	12.29

For Pop. B, the study was carried out by 15 participating countries. As can be seen from Table 12, Japanese achievement was higher than the international average in all content areas. It was especially higher in the areas of Algebra and Geometry, with the area of Sets, Relations and Functions somewhat less significantly better.

5.2 Achievement Comparison Among the Countries on FIMS/SIMS

The FIMS was conducted by IEA in 1964 in 12 participating countries. Among them, ten also participated in SIMS.

Below, comparison between FIMS and SIMS data are made for the following countries: Japan, England, Finland, France, the Netherlands, Sweden and U.S.A..

In Table 13, for Pop. A (students aged 13), achievements in FIMS and SIMS and their differences on 39 anchor items are noted. The average percentage of correct answers in the objective areas of Computation, Comprehension, and

Application and Analysis are given.

Achievement in Japan went up by 3% in the area of Computation, but went down by 2% in the area of Comprehension and 4% in the area requiring a high degree of thinking (Application and Analysis).

Table 13: International Comparison of Anchor Item Achievement (Pop. A)

Country	T			o			p			i			c		
	Overall (39)			Computation (14)			Comprehension (12)			Application & Analysis (13)					
	FIMS (%)	SIMS (%)	D	FIMS (%)	SIMS (%)	D	FIMS (%)	SIMS (%)	D	FIMS (%)	SIMS (%)	D	FIMS (%)	SIMS (%)	D
Japan	64	64	0	64	67	3	56	54	-2	73	69	-4			
England	48	44	-4	48	43	-5	41	40	-1	54	49	-5			
Finland	41	45	4	42	49	7	35	37	2	44	48	4			
France	49	55	6	49	64	15	40	53	13	44	48	4			
Netherlands	47	54	7	52	57	5	36	48	12	51	57	6			
Sweden	37	37	0	38	36	-2	29	32	3	45	44	-1			
U.S.A.	47	46	-1	49	52	3	43	44	1	48	42	-6			

Note: FIMS: First International Mathematics Study
SIMS: Second International Mathematics Study
D: SIMS - FIMS

In terms of overall achievement, the achievement in Finland, France, and the Netherlands went up, but that in England and U.S.A. went down. The achievement in Sweden as well as Japan did not change.

In the Computation level, France made a remarkable improvement, but the achievement in Sweden was worse in the late study than in FIMS.

In the Comprehension level, the achievement in Japan and England at the second testing was worse than that in FIMS, but in other countries it improved. It was remarkably improved in France and the Netherlands.

In the Application/Analysis level, the achievement in SIMS went down in Japan, England, Sweden and U.S.A.. The countries in which the achievement went up in all levels were Finland, France and the Netherlands.

Next, for Pop. B, 24 anchor items were picked up as a whole. Table 14 shows the results computed in the same fashion as for Pop. A. Japan shows improvements in achievement in all levels.

On the other hand, in England, the achievement went down in the levels of Overall, Computation, and Application/Analysis; in Sweden it went down in the level of Application/Analysis, compared to the achievement in the previous study.

Mathematics Achievement of Secondary School Students

Table 14: International Comparison of Anchor Item Achievement (Pop. B)

Country	T			o			p			i			c		
	Overall (24)			Computation (5)			Comprehension (7)			Application & Analysis (12)					
	FIMS (%)	SIMS (%)	D	FIMS (%)	SIMS (%)	D	FIMS (%)	SIMS (%)	D	FIMS (%)	SIMS (%)	D	FIMS (%)	SIMS (%)	D
Japan	61	72	11	81	85	4	60	74	14	53	66	13			
England	64	59	-5	79	77	-2	58	63	5	62	49	-13			
Finland	51	58	7	77	67	-10	51	71	20	40	47	7			
Sweden	52	53	1	62	67	5	50	60	10	49	43	-6			
U.S.A.	30	33	3	46	48	2	31	39	8	23	23	0			

Note: FIMS: First International Mathematics Study
SIMS: Second International Mathematics Study
D: SIMS - FIMS

6. CONCLUSIONS

Student achievement documented in the SIMS study has been discussed for a number of countries, but primarily for our own. From the data and analysis, several generalizations can be made, particularly as they may bear on policy formulation for future goals. These are as follows:

- (1) Although achievement in the fundamental techniques of calculation can be viewed in general as satisfactory, the attainment levels can not be regarded as acceptable for items which require a high degree of thinking and comprehension.
- (2) Specifically, the achievement declined compared with the previous study for such problems as "ratio" and "proportion", which are taught in the upper grades of elementary school, and for verbal problems.
- (3) It might be hypothesized that the introduction of the New Mathematics in the mid-1960's lowered the calculation ability of students in every country. In the case of Japan, however, the contrary seems to be true: calculation ability improved in general, though the achievement levels in items requiring a high degree of thinking and comprehension (which is stressed in the New Mathematics) was not as high as in the prior year.
- (4) For Pop. A (students in lower secondary schools), the change in mathematics scores over the one-year period was measured by pre- and post-tests. The data show that the degree of fixedness was low for verbal items and for items concerning the ratio, proportion and the percentage. From this, it is concluded that more attention must be paid to these matters and to the methods of teaching in the elementary school.

- (5) As was recently found in the case of entrance examinations in Japan, the improvement in calculation ability in this study may be regarded as due partly to "cramming" at some place other than public school (like *Juku* - an informal/outside supplementary school). In order, however, to assure higher scholastic achievement, it is necessary to develop new methods of teaching this subject in the public school setting under conditions which are not so pressureful.

It is our hope to look for and propose new methods for guiding students to the attainment of full and all-round scholastic achievement through a more detailed analysis of data such as these and through comparative perspectives of similar data from other countries.